Private Retirement Savings in Germany: The Structure of Tax Incentives and Annuitization

HANS FEHR
CHRISTIAN HABERMANN

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Abstract

The present paper studies the growth, welfare and efficiency consequences of the recent introduction of tax-favored retirement accounts in Germany in a general equilibrium overlapping generations model with idiosyncratic lifespan and labor income uncertainty. We focus on the implicit differential taxation of specific savings motives, the mandatory annuitization of benefits and the impact of special provisions for low-income households. The simulations indicate that the reform improves overall economic efficiency by about 0.6 percent of aggregate resources, but welfare decreases significantly for future generations. Finally, we show that special provisions could be very effective in raising the participation of low-income households despite their low budgetary cost.

JEL Code: H55, J26.

Keywords: individual retirement accounts, annuities, stochastic general equilibrium.

Hans Fehr
Department of Economics
University of Wuerzburg
Sanderring 2
97070 Würzburg
Germany
hans.fehr@uni-wuerzburg.de

Christian Habermann
Department of Economics
University of Wuerzburg
Sanderring 2
97070 Würzburg
Germany

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1 Introduction

As many other OECD countries before, Germany has introduced a program to promote the development of private pensions savings in 2001. The so-called "Riester pensions"(named after the former secretary of work Walter Riester) are intended to compensate for the phased-in cuts in future public pensions. In principle, the program design is very similar to individual retirement accounts (IRAs) in the US or the United Kingdom. Contributions to these accounts up to a certain contribution limit are voluntary, withdrawal before retirement is restricted, and the savings are tax deferred. Therefore, contributions are tax deductible, the accrued return on investment is tax exempt, but the pension benefits arising from these savings are fully taxed. However, three specific features distinguish the German reform design from the implementation of IRAs in other countries. First, preferential tax treatment of old-age savings is partly financed by an increased taxation of other savings. Second, the program mandates annuitization of the accounts at the time of retirement. Finally, the program provides a direct subsidy which depends on the actual family status and is very generous especially for low-income households with children.

The present paper attempts to quantify the efficiency and distributional consequences of the German Riester accounts. The efficiency effects of the program originate from the differential taxation of saving motives and the implicit provision of a longevity insurance. As Nishiyama and Smetters (2005) have shown, it is not efficient to eliminate the taxation of capital income in a model with labor income uncertainty. Implicitly, capital income taxation acts as an insurance device in such a model which improves economic efficiency. However, uniform taxation of all savings might also not be efficient. Since precautionary savings appear to be less sensitive to changes in the after-tax rate of return than life cycle savings (see Cagetti (2001) or Bernheim (2002, 1199)), an optimal tax structure would tax life cycle savings at a lower rate than precautionary savings. The reduced taxation of savings in retirement accounts could be interpreted as a means to separate the two savings motives. Since accounts are illiquid before retirement, only life cycle savings are allocated there, while precautionary savings are allocated in liquid savings accounts. The mandatory purchase of private life annuities at retirement also has efficiency implications. It is proposed in order to shelter participants against the risk of outliving their assets. When private annuity markets are absent, mandatory annuitization overcomes this market failure and increases aggregate efficiency, see Fehr and Habermann (2008).

The distributional effects of the program work in two directions. First, mandatory annuitization redistributes implicitly from future to existing generations since it reduces unintended bequest. Pecchenino and Pollard (1997) show that the bequest reduction decreases long-run capital accumulation and growth in an endogenous growth model. Fehr and Habermann (2008) demonstrate in an exogenous growth model that future generations will be hurt by annuitization, if the interest rate is sufficiently higher than the growth rate. In the latter case the bequest reduction dominates the benefits from the insurance provision. Second, due to the special provisions for low- and medium-income savers we are also interested in the distributional implications within a cohort. The question is here whether the special provisions are effective in increasing the participation of low- and medium-income households. The answer to this question also determines the effectiveness of the policy to create new savings. As indicated by Benjamin (2003), savings incentives have a significant stronger impact among low-income savers whereas contributions by high-income households are more likely to represent funds shifted from existing savings. In addition, given the progressive income tax system, the budgetary cost of traditional IRA schemes are likely to rise with the income of participants although the effectiveness may well be declining. Consequently, traditional tax deferral is often considered as an expensive means of encouraging additional saving, see the discussion in Bernheim (2002) and OECD (2004).

In order to quantify the efficiency and distributional consequences of the German Riester accounts, we apply a general equilibrium overlapping generations model in the Auerbach-Kotlikoff (1987) tradition which includes mortality and individual income risk as well as borrowing constraints. Private annuity markets are closed by assumption, but the public sector provides partial insurance via the progressive tax system and the unfunded pension system.[1] İmrohoroğlu et al. (1998) evaluate in this framework the long-run consequences of IRAs on the US capital stock for various contribution limits and tax savings instruments. They conclude that about 9 percent of IRA contributions during the 80ies constituted additional savings which raised the US capital stock by about 6 percent. Fuster et al. (2005) extend their framework by introducing mandatory retirement accounts into a model with two-sided altruism where individual life expectancy and income are positively correlated. Their study either eliminates the existing system or substitutes halve of the contributions by mandatory savings in private accounts which are either annuitized or not. While the long-run capital stock increases in all reform scenarios, the mandatory saving programs outperform the full privatization policy in terms of long-run capital and consumption growth.
The present study complements Fehr et al. (2008) who also analyze alternative IRA options for Germany. Compared to the US studies, wo do not only compare steady states,

[1] Krueger (2006) as well as Fehr and Thøgersen (2008) survey recent studies in this tradition.

but compute the complete transition to the new long-run equilibrium in order to quantify the intergenerational welfare consequences. After compensating existing households with lump-sum transfers, we are also able to isolate the overall efficiency consequences of the policy reform. In addition, we include a progressive tax and subsidy system in order to capture the intragenerational implications of the reform. Finally, our model assumes a specific individual preference structure that allows to distinguish the effects of risk aversion and intertemporal substitution.

Our simulations indicate three central results. First, the reform increases economic efficiency by roughly 0.6 percent of aggregate resources. The efficiency gain is mostly due to the fact that the reform improves the insurance properties of the tax system and allows to tax different savings motives separately. Second, despite the significant gains in aggregate efficiency, future generations are most likely hurt by the reform due to the reduction of accidental bequest. In our benchmark calibration, long-run welfare decreases by 0.68 percent of lifetime resources. The welfare losses are stable for a wide range of parameter combinations. Third, the study indicates that the special provisions for low-income households are successful in increasing the participation of this group, but they may have a negative side effect on labor supply.

The next section describes the modeling of the German savings incentive scheme. Then we sketch the structure of the simulation model. Section four explains the calibration and simulation approach. Finally, section five presents the simulation results and section six offers some concluding remarks.

2 Saving incentives for low-income individuals

In order to highlight the central effects of Riester accounts, the modeling of their central elements is highly stylized. Our simulation model simplifies withdrawal restrictions and the annuitization requirement and ignores all transitional provisions for the phase-in period between 2002 and 2008.[2] In order to highlight the very special provisions for low-income individuals, Table 1 compares the benefits from traditional IRAs and from the German system. The left column shows the gross income level of a contributor. As in Germany it is assumed that contributions (s) amount to 4 percent of gross income up to the contribution limit ($\hat{s}$) of 2100 €. The third column reports the marginal tax rate in Germany in year 2005 for a one-earner-couple when the income splitting method

[2] A detailed discussion of the institutional arrangements, the transitional provisions, the changes after 2005 and the recent development of Riester accounts is provided in Börsch-Supan et al. (2007).

Table 1: Benefit payments with alternative saving incentives (in €)

Gross income (1)	IRA contribution (2)	Marginal tax rate (in %) (3)	Traditional IRA scheme (2) × (3) (4)	Direct saving subsidy (5)	German system max[(4), (5)] (6)
10.000	400	0	0	350	350
20.000	800	19	152	350	350
30.000	1200	25	300	350	350
40.000	1600	27	432	350	432
50.000	2100	30	630	350	630
75.000	2100	35	735	350	735
100.000	2100	41	861	350	861

is applied. Column (4) computes the typical benefit in a traditional IRA scheme where contributions could be deducted from the tax base. Due to the rising marginal tax rate, the subsidy rate increases with income so that high-income individuals have a stronger incentive to contribute. The German system also allows such a tax deduction, but provides in addition a direct subsidy (ds) which depends on the family status. If the contribution is at least 4 percent of income, the saving subsidy consists of a basic subsidy of 154 € per adult and an additional child subsidy of 185 €. Consequently, a family with two children could receive about 350 € per adult, as shown in column (5). As in the last column, tax authorities in Germany automatically compute whether the direct subsidy or the tax allowance is optimal for the considered tax payer. Consequently, the German subsidy system offers strong incentives for low- and medium-income families with children.

Of course, the above calculations only serve illustrative purposes. In the simulation model we first compute the advantage da_j of direct subsidies compared to tax deductions at age j from

$$da_j(y_j, s_j) = \max\big[ds_j - (T(y_j, 0) - T(y_j, s_j)), 0\big] \tag{1}$$

where

$$T(y_j, s_j) = T05\big(y_j - \min[s_j, \hat{s}]\big) \tag{2}$$

computes individual income tax payments. The function $T05(\cdot)$ defines the marginal tax schedule in Germany in year 2005 (inclusive solidarity surcharge) and y_j denotes taxable income at age j. Direct subsidies ds_j are zero for traditional IRAs, so that the advantage da_j is zero as well. For the German system we define

$$ds_j = \min\left[\min\left[\frac{s_j}{0.04w_j}, 1\right] tr_j, 0.9s_j\right]. \tag{3}$$

This function includes the fact that direct subsidies are proportionally reduced if the contributions are below 4 percent of annual income w_j. The hump-shaped, age-dependent transfer scheme tr_j tries to capture the changing family status over the life cycle. At age 20-24 transfers start at 200 €, then they increase linearly until they peak at 350 € at age 35-44 and decline again afterwards. However, direct subsidies are not allowed to exceed individual contributions. Therefore, a minimum saving amount is specified which depends on the family status. For simplicity, we assume in the following that 10 percent of contributions have to be at least financed from own resources.
In order to eliminate the liquidity of retirement accounts during employment and avoid positive contributions after retirement, the function

$$\phi_j(s_j) = \begin{cases} s_j & \text{if} \quad j < j_R \quad \text{and} \quad s_j \leq 0 \\ da_j & \text{if} \quad j < j_R \quad \text{and} \quad s_j > 0 \\ -\infty & \text{if} \quad j \geq j_R \quad \text{and} \quad s_j > 0 \\ 0 & \text{else.} \end{cases} \tag{4}$$

is added to the budget constraint (8). Consequently, before retirement (i.e. at age $j < j_R$) withdrawals from IRAs are not possible, since all the money would be lost.[3] On the other hand, positive contributions could induce a public transfer da_j before retirement and a prohibitive penalty if they are made after retirement.

3 The model economy

3.1 Demographics and intracohort heterogeneity

We consider an economy populated by overlapping generations of individuals which may live up to a maximum possible lifespan of J periods. At each date, a new generation is born where we have normalized its size $N_1 = 1$, i.e. we assume zero population growth. Since individuals face lifespan uncertainty with $\psi_j < 1$ the time-invariant conditional survival probability from age $j-1$ to age j, i.e. $N_j = \psi_j N_{j-1}$ and $\psi_{J+1} = 0$.
Our model is solved recursively. Consequently, an agent faces the state vector $z_j = (j, \mathrm{a}_j, \mathrm{a}_j^R, ep_j, e_j)$ where $j \in \mathcal{J} = \{1, \ldots, J\}$ is the household's age, $\mathrm{a}_j \in A = [\underline{\mathrm{a}}, \bar{\mathrm{a}}]$ denotes (liquid) assets held at the beginning of age j, $\mathrm{a}_j^R \in R = [\underline{\mathrm{a}}^R, \bar{\mathrm{a}}^R]$ denotes assets in individual retirement accounts held at the beginning of age j, $ep_j \in P = [\underline{ep}, \overline{ep}]$ defines the agent's accumulated earning points for public pension claims and $e_j \in E_j = [\underline{e}_j, \overline{e}_j]$ is the individual productivity at age j.

[3]Of course, it would be no problem to consider lower penalties, see Fehr et al. (2008).

Since income is uncertain the productivity state is assumed to follow a first-order Markov process described in more detail below. Consequently, each age-j cohort is fragmented into subgroups $\xi(z_j)$, according to the initial distribution (i.e. at $j = 1$), the Markov process and optimal decisions. Let $X(z_j)$ be the corresponding cumulated measure to $\xi(z_j)$. Hence,

$$\int_{A\times R\times P\times E_j} \mathrm{d}X(z_j) = 1 \quad \text{for all} \quad j = 1, \ldots, J$$

must hold, as $\xi(z_j)$ is not affected by cohort sizes but only gives densities within cohorts. In the following, we concentrate on the long-run equilibrium and omit the time index t and the state index z_j for every variable whenever possible. Agents are then only distinguished according to their age j.

3.2 The household side

Our model assumes a preference structure that is represented by a time-separable, nested CES utility function. In order to isolate risk aversion from intertemporal substitution, we follow the approach of Epstein and Zin (1991) and formulate the maximization problem of a representative consumer at age j and state z_j recursively as

$$V(z_j) = \max_{\ell_j, c_j, s_j} \left\{ u(c_j, \ell_j)^{1-\frac{1}{\gamma}} + \delta \left[\psi_{j+1} E[V(z_{j+1})]^{1-\frac{1}{\gamma}} + (1-\psi_{j+1})\mu q_{j+1}^{1-\frac{1}{\gamma}} \right] \right\}^{\frac{1}{1-\frac{1}{\gamma}}} \tag{5}$$

with

$$E[V(z_{j+1})] = \left[\int_{E_{j+1}} \pi(e_{j+1}|e_j) V(z_{j+1})^{1-\eta} \mathrm{d}e_{j+1} \right]^{\frac{1}{1-\eta}}. \tag{6}$$

In (5) the variables ℓ_j, c_j and q_{j+1} denote leisure, consumption and bequest at age j, respectively. The parameters δ and γ represent the discount rate and the intertemporal elasticity of substitution between consumption in different years while μ defines the strength of the bequest motive. Since lifespan is uncertain, the expected utility in future periods is weighted with the survival probability ψ_{j+1}. Productivity e_j at each age j is uncertain and depends on the productivity in the previous period. Consequently, $\pi(e_{j+1}|e_j)$ in (6) denotes the probability to experience productivity e_{j+1} in the next period if the current productivity is e_j. The parameter η defines the degree of (relative) risk aversion. Note that for the special case $\eta = \frac{1}{\gamma}$ we are back at the traditional expected utility specification, see Epstein and Zin (1991, 266). The period utility function is defined by

$$u(c_j, \ell_j) = \left[(c_j)^{1-\frac{1}{\rho}} + \alpha(\ell_j)^{1-\frac{1}{\rho}} \right]^{\frac{1}{1-\frac{1}{\rho}}} \tag{7}$$

where ρ denotes the intratemporal elasticity of substitution between consumption and leisure at each age j. Finally, the leisure preference parameter α is assumed to be age independent.

The budget constraint is defined as follows:

$$\mathrm{a}_{j+1} = \mathrm{a}_j(1+r)+w_j+p_j+b_j+v_j-\tau \min[w_j; 2\bar{w}]-s_j-[T(y_j, s_j)-\phi_j(s_j)]-(1+\tau_c)c_j \quad (8)$$

with $\mathrm{a}_1 = 0$ and $\mathrm{a}_j \geq 0 \; \forall \; j$. In addition to interest income from savings $r\mathrm{a}_j$, households receive gross labor income $w_j = w(1-\ell_j)e_j$ during their working period as well as public pensions p_j during retirement. As time endowment is normalized to one, $1-\ell_j$ defines working time and w the wage rate for effective labor. They may receive (accidental) bequests b_j and in some simulations they receive (or have to finance) compensation payments v_j which are explained below. During employment, they contribute to the public pensions system but only up to the contribution ceiling which amounts to the double of average income $\bar{w}$. They also contribute to or withdraw from retirement accounts s_j and have to pay progressive income taxes $T(\cdot)$ where in some cases the direct subsidies are subtracted. All remaining income is used for consumption where the consumer price includes consumption taxes τ_c.

Retirement account assets accumulate according to

$$\mathrm{a}^R_{j+1} = \mathrm{a}^R_j(1+r_j)+\min[s_j, \hat{s}] \qquad \text{with} \quad r_j = \frac{1+r}{\max[\omega_j, \psi_j]}-1 \quad (9)$$

where $\mathrm{a}^R_1 = 0$ and $\mathrm{a}^R_j \geq 0 \; \forall \; j$. Without annuitization at age j, we set $\omega_j = 1$, so that the survival probability ψ_j has no effect on the individual return, i.e. $r_j = r$. If retirement account assets are annuitized at age j, we set $\omega_j = 0$, so that the periodic returns are annuitized, i.e. $r_j > r$. Note that contributions cannot exceed the contribution limit $\hat{s}$. After retirement (i.e. $j \geq j_R$ and $s_j \leq 0$) we have to distinguish two cases: First, without mandatory annuitization, retired households can decide how much to withdraw. Second, with mandatory annuitization, retirees receive a fixed benefit depending on their wealth at the beginning of retirement $\mathrm{a}^R_{j_R}$:

$$s_j = -\frac{(1+r_{j_R})\mathrm{a}^R_{j_R}}{\sum_{j=j_R}^{J} \Pi_{i=j_R+1}^{j}(1+r_i)^{-1}}. \quad (10)$$

Our model abstracts from other annuity markets. Consequently, private assets and non-annuitized retirement account assets of all agents who died are aggregated and then distributed among all working age cohorts following an exogenous age- and productivity-dependent distribution scheme $\Gamma_j(e_j)$, i.e.

$$b_j = \Gamma_j(e_j)\sum_{i=1}^{J}(1-\psi_{i+1})N_i\int_{A\times R\times P\times E_i} q_{i+1}(z_i)\mathrm{d}X(z_i) \quad \text{for all} \quad j = 1,\ldots,j_{R-1}, \quad (11)$$

where $q_{i+1}(z_i) = (1 + r)[\mathrm{a}_{i+1}(z_i) + \omega_{i+1}\mathrm{a}^R_{i+1}(z_i)(1 - \tau_b)]$. The age distribution of bequests is computed in the initial steady state where we assume that the heirs always receive the assets of the generation which was 25 years older. Since bequest can be received only during employment, we adjust this rule at the beginning and at the end of employment. Within a generation bequests are distributed proportional to the current productivity level e_j, which highlights their stochastic nature and also reflects empirical evidence.[4] Finally, inheritances from IRAs are due to a specific inheritance tax τ_b since they were accumulated tax free.[5]

3.3 The production side

Firms in this economy use capital and labor to produce a single good according to the Cobb-Douglas production technology $Y = \varrho K^{\varepsilon} L^{1-\varepsilon}$ where Y, K and L are aggregate output, capital and labor, ε is capital's share in production, and ϱ defines a technology parameter. Capital depreciates at a constant rate δ_k and firms have to pay corporate taxes $T_k = \tau_k\big[Y - wL - \delta_k K\big]$ where the corporate tax rate τ_k is applied to the output net of labor costs and depreciation. Firms maximize profits renting capital and hiring labor from the households so that the marginal product of capital net of depreciation and corporate taxes equals the market interest rate r and the marginal product of labor equals the wage rate w for effective labor.

3.4 The government sector

Our model distinguishes between the tax system and the pension system. In each period the government issues new debt ΔB and collects taxes from households and firms in order to finance general government expenditures G as well as interest payments on its debt. Whereas government purchases of goods and services G are fixed per capita, we assume a constant debt to output ratio of 60 percent in the benchmark case. Consequently, the long-run equilibrium (i.e. where $\Delta B = 0$) government budget is defined by

$$G + rB = T_y + \tau_c C + T_b + T_k, \qquad (12)$$

[4] De Nardi (2004) highlights the link between individual productivity and inheritance. Fehr et al. (2008) also report the consequences of alternative bequest distributions.

[5] If account owners in Germany die before retirement, their heirs have to pay back all the tax benefits received in former periods if the wealth is not transferred to another retirement account.

where C defines aggregate consumption (see equation (20)) and revenues of income and bequest taxation are computed from

$$T_y = \sum_{j=1}^{J} N_j \int_{A\times R\times P\times E_j} [T(y_j(z_j), s_j(z_j)) - \phi_j(s_j(z_j))]\mathrm{d}X(z_j)$$

and

$$T_b = \tau_b \sum_{j=1}^{J} N_j \int_{A\times R\times P\times E_j} \omega_{j+1}(1-\psi_{j+1})(1+r)\mathrm{a}_{j+1}^{R}(z_j)\mathrm{d}X(z_j).$$

We assume that contributions to public pensions are exempted from tax while the benefits are fully taxed. Consequently, taxable gross income y_j is computed from gross labor income net of pension contributions and a fixed work related allowance d_w, nominal[6] capital income net of a saving allowance d_s and - after retirement - public pensions

$$y_j = \max[w_j - \tau \min[w_j; 2\bar{w}] - d_w; 0] + \max[\tilde{r}\mathrm{a}_j - d_s; 0] + p_j. \tag{13}$$

Note that we do not include interest income from retirement accounts.
The pension system pays old-age benefits and collects payroll contributions from wage income below the contribution ceiling which is fixed at two times the average income $\bar{w}$. Individual pension benefits p_j of a retiree of age $j \geq j_R$ in a specific year are computed from the product of his earning points ep_{j_R} the retiree has accumulated at retirement and the actual pension amount (APA) of the respective year:

$$p_j = ep_{j_R} \times APA. \tag{14}$$

In each year of employment, the worker receives an earning point depending on his relative income position $w_j/\bar{w}$ up to the contribution ceiling. Since the latter is fixed at the double of average income $\bar{w}$, the maximum earning points that could be collected per year are 2. Accumulated earning points at age j are therefore

$$ep_{j+1} = ep_j + \min[w_j/\bar{w}; 2], \tag{15}$$

with $ep_1 = 0$.
The budget of the pension system must be balanced in every period. Consequently, the general contribution rate τ is computed from

$$\tau = \frac{\sum_{j=j_R}^{J} N_j \int_{A\times R\times P\times E_j} p_j(z_j)\mathrm{d}X(z_j)}{\sum_{j=1}^{j_R-1} N_j \int_{A\times R\times P\times E_j} \min[w_j(z_j); 2\bar{w}]\mathrm{d}X(z_j)}. \tag{16}$$

[6] In order to reflect realistic features of capital income taxation in a model without inflation, we assume for taxation purposes a nominal interest rate $\tilde{r}$, i.e. real interest rate r plus a fictive inflation of two percent per year. The latter exacerbates the distortions of *real* capital income taxation, see Feldstein (1997).

3.5 Equilibrium and the computational method

Given the fiscal policy $\{G, B, T05(.), \tau_b, \tau_c, \tau_k, \tau, \phi, \omega, \hat{s}\}$, a stationary recursive equilibrium is a set of bequests $\{b(z_j)\}_{j=1}^{J}$, value functions $\{V(z_j)\}_{j=1}^{J}$, household decision rules $\{c_j(z_j), \ell_j(z_j), s_j(z_j)\}_{j=1}^{J}$, time-invariant measures of households $\{\xi(z_j)\}_{j=1}^{J}$ and relative prices of labor and capital $\{w, r\}$ such that the following conditions are satisfied:

1. given fiscal policy, factor prices and bequests, households' decision rules solve the households decision problem (5);

2. factor prices are competitive, i.e.

$$w = (1-\varepsilon)\varrho\left(\frac{K}{L}\right)^{\varepsilon} \tag{17}$$

$$r = (1-\tau_k)\left[\varepsilon\varrho\left(\frac{L}{K}\right)^{1-\varepsilon} - \delta_k\right] \tag{18}$$

3. in the closed economy aggregation holds,

$$L = \sum_j N_j \int_{A\times R\times P\times E_j} (1-\ell(z_j))e_j \mathrm{d}X(z_j) \tag{19}$$

$$C = \sum_j N_j \int_{A\times R\times P\times E_j} c_j(z_j)\mathrm{d}X(z_j) \tag{20}$$

$$K = \sum_j N_j \int_{A\times R\times P\times E_j} (\mathrm{a}_j + \mathrm{a}_j^R)\mathrm{d}X(z_j) - B. \tag{21}$$

4. Let $\mathbf{1}_{h=x}$ be an indicator function that returns 1 if $h = x$ and 0 if $h \neq x$. Then, the law of motion of the measure of households is, for $j \in \mathcal{J}$,

$$\xi(z_j) = \int_{A\times R\times P\times E_{j-1}} \mathbf{1}_{\mathrm{a}_j=\mathrm{a}_j(z_{j-1})} \times \mathbf{1}_{\mathrm{a}_j^R=\mathrm{a}_j^R(z_{j-1})} \times \mathbf{1}_{ep_j=ep_j(z_{j-1})}\pi_{j-1}(e_j, e_{j-1})\mathrm{d}X(z_{j-1}).$$

5. bequests satisfy

$$\sum_{j=1}^{j_R-1} N_j \int_{A\times R\times P\times E_j} b_j(z_j)\mathrm{d}X(z_j) = \sum_{i=1}^{J}(1-\psi_{i+1})N_i \int_{A\times R\times P\times E_i} q_{i+1}(z_i)\mathrm{d}X(z_i). \tag{22}$$

6. the government budget (12) as well as the budget of the pension system (16) are balanced intertemporally;

7. the goods market clears, i.e.

$$Y = C + \delta_k K + G.$$

The computation method follows the Gauss-Seidel procedure of Auerbach and Kotlikoff (1987). For the initial steady state which reflects the current German tax and social security system without retirement accounts, we start with a guess for aggregate variables, bequests distribution and exogenous policy parameters. Then we compute the factor prices, the individual decision rules and value functions. The latter involves the discretization of the state space which is explained in the appendix. Next we obtain the distribution of households and aggregate assets, labor supply and consumption as well as the social security tax rate and the consumption tax (or surcharge) rate that balances government budgets. This information allows us to update the initial guesses. The procedure is repeated until the initial guesses and the resulting values for capital, labor, bequests and endogenous taxes have sufficiently converged.
Next we solve for the transition path after the introduction of retirement accounts. We assume that the transition between the initial and the new final steady state takes $4 \times J$ periods. Given the alternative policy parameters we assume in the first guess that aggregate values and bequests of the initial equilibrium remain constant along the transition. Then we update for each period of the transition the individual and aggregate variables until we reach convergence.

4 Calibration of the initial equilibrium

In order to reduce computational time, each model period covers five years. Agents start life at age 20 ($j = 1$), are forced to retire at age 60 ($j_R = 9$) and face a maximum possible life span of 100 years ($J = 16$). The conditional survival probabilities ψ_j are computed from the year 2000 Life Tables reported in Bomsdorf (2003). With respect to the preference parameters we set the intertemporal elasticity of substitution γ to 0.5, the intratemporal elasticity of substitution ρ to 0.6, the coefficient of relative risk aversion η to 4.0 and the leisure preference parameter α to 1.5. This is within the range of commonly used values (see Auerbach and Kotlikoff, 1987) and yields a compensated wage elasticity of labor supply of 0.3 in our benchmark. Finally, we abstract from bequest motives (i.e. set $\mu = 0.0$) and set the time preference rate δ to 0.9 in order to calibrate a realistic capital to output ratio, which implies an annual discount rate of about 2 percent.
With respect to technology parameters we chose the general factor productivity $\varrho = 1.5$ in order to normalize labor income and set the capital share in production ε at 0.3. The annual depreciation rate for capital is set at $\delta_k = 0.06$. The annual APA value is currently about 310 €. We have adjusted this amount slightly in order to derive a realistic standard

pension[7] and contribution rate for Germany. As already explained, the taxation of gross income (from labor, capital and pensions) is close to the current German income tax code and the marginal tax rate schedule introduced in 2005. We assume that our households are married couples with a sole wage earner and apply the German income splitting method. In addition, we consider a special allowance for labor income of $d_w = 1200$ € while for capital income the special allowance amounts to $d_s = 3600$ € (per couple)[8]. Given taxable income y_j the marginal tax rate rises linearly after the basic allowance of 7800 € from 15 percent to maximum of 42 percent when y_j passes 52.000 €. In addition to the income tax payment, households pay a surcharge of 5.5 percent of income taxes. The consumption tax rate is set at $\tau_c = 0.17$ and the corporate tax rate is fixed at $\tau_k = 0.15$. Since the benchmark equilibrium is without retirement accounts, we set $\hat{s} = 0$.

In order to model the income process, we distinguish six productivity profiles across the life cycle. Fehr (1999) has estimated five such profiles from data of the German Socio-Economic Panel Study (SOEP). We split up the profile of the lowest income class in order to improve the income distribution. When an agent enters the labor market (at age 20-24) he belongs to the lowest productivity level with a probability of 10 percent, to the second lowest again with 10 percent and to higher levels with 20 percent, respectively. After the initial period, agents change their productivity levels according to the age-specific Markov transition matrices which are reported in the appendix. The latter are computed also from SOEP data for different years between 1988 and 2003. Specifically we sorted the primary earners of the years 1988, 1993 and 1998 into seven cohorts and divided them within each cohort into six income classes. Then we compiled for each cohort and income class the respective income classes of its members in the surveys of the years 1993, 1998 and 2003 in order to calculate the age-specific transition matrices.

Table 2 reports the calibrated benchmark equilibrium and the respective figures for Germany in 2005. The reported bequest in Table 2 are purely accidental since annuity markets are missing. The (endogenous) consumption tax rate is 17 percent which is quite realistic for Germany.

The models income and wealth distribution is more equal than in reality. Partly this reflects the fact that the share of younger cohorts (i.e. those cohorts where income and wealth are less dispersed) in the total population of the model is higher than in Germany. Note that the two lowest productivity classes of the youngest cohort would like to borrow

[7]The standard pension in Germany is computed for a worker who has received an average wage during employment - i.e. $ep_{j_R} = j_R - 1$ - and amounts to roughly 60 percent of net average earnings.

[8]In Germany this allowance is currently 3000 € for nominal interest income, but 6000 € if the source of capital income are dividends.

Table 2: The initial equilibrium

	Model solution	Germany 2005*
Pension benefits (% of GDP)	13.1	12.7
Pension contribution rate (in %)	19.5	19.5
Tax revenues (in % of GDP)	20.3	20.0
Average income tax rate (in %)	7.9	–
Interest rate p.a. (in %)	3.4	–
Bequest (in % of GDP)	4.3	5.2
Capital-output ratio	2.9	3.0
Gini index net income	0.296	0.299
Gini index wealth	0.540	0.613
Households with borrowing constraints (in %)		
age 20-24	20.0	10.0
age 25-29	7.3	18.9
age 30-34	5.5	18.9
age 35-39	4.1	17.1
age 40-44	2.5	17.1

*Source: IdW(2007), DIW (2005), SAVE survey.

because they expect a higher productivity (and therefore income) in the future. For older cohorts, the fraction of liquidity constraint agents decreases sharply. After age 35 we hardly observe liquidity constrained households. Recent evidence from the SAVE survey indicates that our model exaggerates borrowing constraints at young ages but understates the constraints in middle-ages.

5 Simulation results

This section presents the quantitative results when we simulate the German Riester reform in four successive steps. In the first simulation we increase the taxation of capital income. Then we introduce traditional IRAs without mandatory annuitization. Next, the IRAs are annuitized after retirement and in the final step we add the special provisions for low-income households. The following subsection explains some technical details of the computation. Then we discuss the macroeconomic and welfare effects of the considered policy reforms.

5.1 Experimental design and welfare computation

Our four reform simulations can be distinguished by alternative combinations of $d_s, \tau_b, \hat{s}, \omega_j$ and tr_j. In the benchmark equilibrium of Table 2 these parameters are set at $d_s = 1.800$ €, $\tau_b = \hat{s} = tr_j = 0$ and $\omega_j = 1$. In the first simulation we simply eliminate the saving allowance (i.e. we set $d_s = 0$).[9] Next we combine the increase of ordinary capital income taxation with the introduction of traditional IRAs, i.e. $d_s = 0$ and $\hat{s} = 2.100$ €. Due to the deferred taxation we assume that inheritances from these accounts are taxed at $\tau_b = 0.165$, which equals the average marginal income tax rate in the benchmark. In the third simulation we add the annuitization of the accounts at the time of retirement, i.e. $\omega_j = 1$ if $j < j_R$ and $\omega_j = 0$ if $j \geq j_R$. Finally, we introduce $tr_j > 0$ in oder to arrive at the German system.

Of course, all policy reforms affect the tax revenues of the government. In order to balance the intertemporal budget we compute a time-invariant consumption tax rate τ_c from

$$\tau_c = \frac{B_1 + \sum_{t=1}^{\infty} \left[G - T_{y,t} - T_{b,t} - T_{k,t}\right](1+r)^{1-t}}{\sum_{t=1}^{\infty} C_t(1+r)^{1-t}}.$$

The periodical budget is then balanced by the endogenous debt level, i.e.

$$B_{t+1} = B_t(1+r) + G - T_{y,t} - \tau_c C_t - T_{b,t} - T_{k,t}.$$

Next we turn to the computation of the welfare changes. The welfare criterion which is applied to assess a reform is ex-ante expected utility of an agent, before the productivity level is revealed. For an agent who enters the labor market the expected utility is computed from

$$E[V(z_1)] = \left[\int_{E_1} \xi(z_1)V(z_1)^{1-\eta}\mathrm{d}e_1\right]^{\frac{1}{1-\eta}}. \tag{23}$$

We assume that the reform is implemented after agents know that they have survived but before the productivity shock is revealed. Consequently, the individual welfare effect is derived from the expected utilities in the initial equilibrium and after the reform announcement. Following Auerbach and Kotlikoff (1987, 87) we compute the proportional increase in consumption and leisure (W) which would make an agent in the baseline scenario as well off as in the reform scenario. If the expected utility level of an individual age j in year t after the reform is $E[V(z_{j,t})]$ and the expected utility level on the baseline path is $E[V(z_{j,0})]$, the necessary increase (decrease) in percent of initial resources is computed

[9] Note, however, the saving allowance was not completely eliminated but only severely reduced in Germany during the last years.

from

$$W_{j,t} = \left[\frac{E[V(z_{j,t})]}{E[V(z_{j,0})]} - 1\right] \times 100 \tag{24}$$

for individuals born before and after the reform. Consequently, a value of $W_{j,t} = 1.0$ indicates that this agent would need one percent more resources in the baseline scenario to attain expected utility $E[V(z_{j,t})]$.

In order to asses the aggregate efficiency consequences, we introduce a Lump-Sum Redistribution Authority (LSRA) in the spirit of Auerbach and Kotlikoff (1987, 65f.) as well as Nishiyama and Smetters (2005) and Fehr et al. (2008). The LSRA pays a lump-sum transfer (or levies a lump-sum tax) to each living household in the first period of the transition to bring their expected utility level back to the level of the initial equilibrium. Consequently, age-j agents who were alive in the initial equilibrium are compensated by the transfers $v_{j,1}(W_{j,1} = 0)$, that depend on their status in the initial equilibrium and guaranty the initial expected utility level $E[V(z_{j,0})]$. On the other hand, those who enter the labor market in period t of the transition receive a transfer $v_{1,t}(W_{1,t} = W^*)$ which guaranties them an expected utility level $E[V(z_{1,t})] = V^*$. Note that the transfers $v_{1,t}$ may differ among future cohorts but the expected utility level V^* is identical for all. The value of the latter is chosen by requiring that the present value of all LSRA transfers is zero:

$$\sum_{j=2}^{J} N_j \int_{A\times R\times P\times E_j} v_{j,1}(W_{j,1} = 0)dX(z_j) + \sum_{t=1}^{\infty} v_{1,t}(W_{1,t} = W^*)N_1(1+r)^{1-t} = 0. \tag{25}$$

With $V^* > E[V(z_{1,0})]$ (i.e. $W^* > 0$), all households in period one who have lived in the previous period would be as well off as before the reform and all current and future newborn households would be strictly better off. Hence, the new policy is Pareto improving after lump-sum redistributions. With $V^* < E[V(z_{1,0})]$ (i.e. $W^* < 0$), the policy reform is Pareto inferior after lump-sum redistributions.

5.2 Macroeconomic effects of savings incentives

This section discusses the macroeconomic effects of the simulated reforms. The first column ("Capital income taxation") in Table 3 reports the changes in central macro variables when we extend the taxation of capital income by eliminating the capital allowance.[10]

The elimination of capital income allowances allows to reduce the consumption tax rate by 1.7 percentage points. Aggregate savings decrease by roughly 4.4 percent in the long-run. Since public debt remains almost constant in the long-run, the capital stock even

[10] The reform starts in the second period, since we don't want to alter the taxation of existing assets.

Table 3: Macroeconomic effects of savings taxation and retirement accounts

	Capital income taxation ($d_s = 0$)	Introduction of retirement accounts		
		Traditional IRA	Annuitized IRA	German system
Savings[a]				
2010-14	0.2	1.2	1.0	0.9
2015-19	-1.3	0.9	0.5	0.2
2025-29	-3.1	2.1	0.8	0.5
∞	-4.4	7.7	3.9	3.9
IRA share in savings (in %)				
2010-14	0.0	5.5	6.3	6.4
2015-19	0.0	11.8	12.9	13.2
2025-29	0.0	26.0	26.1	26.6
∞	0.0	44.5	46.2	46.9
Capital stock[a]				
2010-14	-1.4	-0.2	-0.4	-0.6
2015-19	-2.9	-0.6	-1.1	-1.3
2025-29	-4.5	-0.3	-1.6	-1.9
∞	-5.7	2.2	-1.8	-1.9
Labor supply[a]				
2005-09	-0.1	0.3	-0.1	-0.5
2015-19	-0.4	-0.3	-0.7	-1.0
2025-29	-0.2	-0.1	-0.6	-1.0
∞	-0.1	-0.2	0.3	0.0
Wages[a]				
2005-09	0.0	-0.1	0.0	0.1
2015-19	-0.7	-0.1	-0.1	-0.1
2025-29	-1.3	-0.1	-0.3	-0.3
∞	-1.7	0.7	-0.6	-0.6
Public debt (in % of GDP)				
2010-14	64.8	64.7	64.8	65.0
2015-19	64.1	65.0	65.1	65.1
2025-29	63.0	68.5	68.0	68.1
∞	62.2	80.0	79.1	79.6
Bequest[a]				
2005-09	0.0	0.1	0.0	-0.1
2015-19	-1.2	-0.9	-2.9	-3.0
2025-29	-2.5	-0.1	-12.3	-12.5
∞	-4.1	12.9	-45.2	-45.6
Consumption tax rate (in percentage points)				
2005-	-1.7	-0.3	-0.2	0.2

[a]Changes are reported in percentage over initial equilibrium.

decreases by 5.7 percent, so that the interest rate increases by about 0.3 percentage points. The lower capital stock reduces wages and labor supply. Finally, due to lower savings also accidental bequest decrease by about 4 percent in the long-run.

In the following two simulations, we keep the full taxation of ordinary asset returns but introduce retirement accounts without ("Traditional IRA") and with ("Annuitized IRA") mandatory annuitization of benefits after retirement. Younger and future generations now increase savings in tax-favored accounts so that aggregate savings rise throughout the transition. Since tax revenues decline and are shifted from current to future periods, the consumption tax rate is higher than in the first simulation and public debt increases during the transition. Due to higher public debt, the capital stock and wages only increase slightly in the long-run without annuitization. Note that we would get quite similar effects for savings and the capital stock as İmrohoroğlu et al. (1998) if we would not alter capital income taxation. From the figures in Table 3 we can also compute that in the long-run about 16 percent of IRA contributions represent new savings. [11] This corresponds quite well with Attanasio and DeLeire (2002) who found that in the United Kingdom about 9 percent of IRA contributions are from new savings.

However, matters are quite different when we introduce annuitized accounts in the next simulation. Assets of deceased are now transferred to surviving elderly. Consequently, while bequests still increase in the second simulation, they decrease now dramatically so that long-run savings and the capital stock are much lower than before. In the last column ("German system") we keep annuitization but introduce the direct savings subsidies. Of course, such a program increases cost, therefore the consumption tax has to rise while savings and the capital stock change as before. In the German system, those people who contribute less than 4 percent of their income can increase the transfer rate for given savings if they work less, see the definition (3). Consequently, this feature of the saving subsidy design induces a negative labor supply effect which is evident in Table 3.

Whereas Table 3 documents that the share of savings in retirement accounts rises during the transition, Table 4 reports how cohorts contribute to the accounts in the new long-run equilibrium. People first have to build up precautionary savings against income uncertainty. Consequently, 60 percent of the youngest cohort do not contribute to the accounts at all. With rising age participation rates and contributions increase since existing precautionary savings reduce the exposure to income uncertainty.[12] Note that with annuitized accounts contributions rise especially before retirement. Since after retirement

[11] This figure is derived from $\frac{1}{0.445}(1 - \frac{1}{1.077}) = 0.161$.

[12] This corresponds to the findings of Hrung (2002) who shows that in the U.S. IRA savings are lower for individuals exposed to high income risk.

income uncertainty is eliminated, precautionary savings are reshuffled to retirement accounts in order to increase longevity insurance. Börsch-Supan et al. (2007, 18) confirm for Germany that participation increases with age initially but then it declines again after age 50. Currently Riester pensions are most common in the 30 to 49 age group. One reason for the low participation rate among elderly might be that our model does not reflect the transitional period between 2002 and 2008 where subsidy payments were much lower and the regulation of Riester pensions was more complicated. In addition, we also do not consider the future reduction of public pension benefits. The latter induces a clear incentive especially for middle-age and young individuals to save more for retirement.

Table 4: Average participation in retirement accounts (in %)

	Traditional IRA			Annuitized IRA			German system		
Age	$s_j = 0$	$0 < s_j < \hat{s}$	$s_j = \hat{s}$	$s_j = 0$	$0 < s_j < \hat{s}$	$s_j = \hat{s}$	$s_j = 0$	$0 < s_j < \hat{s}$	$s_j = \hat{s}$
20-24	60	20	20	60	20	20	60	20	20
25-29	49	12	39	44	17	39	0	61	39
30-34	40	06	55	34	09	57	0	48	52
35-39	24	19	58	20	16	64	0	44	56
40-44	18	16	66	15	15	70	0	38	62
45-49	17	14	69	15	11	74	1	29	70
50-54	17	11	71	16	9	76	3	22	75
55-59	19	17	64	14	6	81	3	17	80

Apart from the initial cohorts, the German system in the right part of Table 4 induces an extremely high participation rate. Of course, this mainly reflects changes in the behavior of low-income households. Table 5 compares the participation rate of the bottom decile in the traditional retirement account with annuitization and in the German system. Whereas with traditional accounts still 56 percent of the bottom decile don't contribute at all in the period before retirement, this fraction decreases to 13 percent in the German system. Consequently, the direct subsidy payments are quite effective in increasing participation and contributions among low-income households. This is also confirmed by Börsch-Supan et al. (2007, 19) who document that Riester accounts are particularly popular among larger families with children.

5.3 Welfare effects of saving incentives

Next we turn to welfare consequences for different cohorts in the reform year and the long-run without and with compensation payments from the LSRA. As already explained

Table 5: Participation of low-income households (in %)

Age	Annuitized IRA			German system		
	$s_j = 0$	$0 < s_j < \hat{s}$	$s_j = \hat{s}$	$s_j = 0$	$0 < s_j < \hat{s}$	$s_j = \hat{s}$
20-24	100	0	0	100	0	0
25-29	100	0	0	0	100	0
30-34	99	1	0	0	100	0
35-39	90	8	2	0	100	0
40-44	74	23	3	0	98	2
45-49	72	18	10	1	92	7
50-54	65	18	17	5	79	16
55-59	56	20	24	13	64	23

above, we first compute the welfare changes of agents before their productivity is revealed and then derive an average welfare change for the different productivity types in each cohort that already lives in the initial equilibrium. Therefore, Table 6 distinguishes in each cohort between "poor","median", and "rich" households. "Poor" agents are the 10 percent of the cohort with the lowest realized productivity level, "median" are those 20 percent who realize a medium productivity level and "rich" are those 20 percent of the cohort with the highest productivity.[13] For newborn cohorts along the transition path we are not able to disaggregate ex-ante welfare effects. Consequently, we report in the middle column the ex-ante welfare change of the whole cohort and in brackets the (ex-post) welfare changes for "poor" and "rich" newborn households after their productivity is revealed to them. Table 6 compares the extension of capital income taxation and the introduction of (non-annuitized) traditional retirement accounts in the present model.
Not surprisingly, an increase in capital income taxation balanced by reduced consumption taxes is especially beneficial for medium and old-aged households with low wealth holdings. All households gain from the reduction of consumption taxation, but poor elderly are also hardly affected by the increase in capital income taxation. While medium-aged households have build-up assets already, they are hurt by the increase of capital income taxation. Since the reform reduces wages in the long-run significantly, generations born in the future lose. The differences within the cohorts are rather insignificant. Next we simulate the reform with lump-sum compensation payments of the LSRA in order to isolate the aggregate efficiency consequences of the rise in capital income taxation.[14] The

[13]For pensioners we aggregate the respective fractions in earning points.

[14]We do not report the macroeconomic effects of simulations with compensation payments, but they

compensated welfare changes for all generations alive in the initial equilibrium are then zero and newborn generations experience identical relative consumption increases. As shown in the forth column, rising capital income taxes increase aggregate efficiency by 0.35 percent of remaining resources. This is due to the fact that the reformed tax system (with more income and less consumption taxation) offers more income insurance.[15]

Table 6: Welfare effects of alternative capital income tax regimes

Age in reform year	Capital income taxation				Traditional IRA			
	Consumers			compen-	Consumers			compen-
	poor	median	rich	sated	poor	median	rich	sated
90-94	1.11	0.98	0.90	0.00	0.22	0.20	0.18	0.00
80-84	1.03	0.93	0.83	0.00	0.22	0.19	0.15	0.00
60-64	0.95	0.41	0.13	0.00	0.01	-0.36	-0.57	0.00
40-44	0.53	0.22	0.12	0.00	0.20	0.07	-0.08	0.00
20-24	(0.35)	0.20	(0.00)	0.35	(0.12)	0.07	(0.05)	0.06
0-4	(-0.20)	-0.22	(-0.27)	0.35	(0.17)	0.11	(0.01)	0.06
∞	(-0.35)	-0.33	(-0.36)	0.35	(0.56)	0.42	(0.24)	0.06

[a]Change are reported in percentage of initial resources.

The introduction of (non-annuitized) traditional retirement accounts in the right part of Table 6 neutralizes (at least partly) the increase in capital income taxation. Since consumption taxes fall much less, the welfare gains of already retired generations are now much lower than in the first simulation. Medium-income and rich households who retire in the reform year even experience significant welfare losses. They can't benefit from the new accounts, consequently they fully bear the increase of capital income taxes but now they benefit from reduced consumption taxes much less. Welfare of newborn and future generations now increases after the reform since these cohorts can reduce their capital income tax burden significantly by saving in the accounts and long-run wages increase now slightly. Since higher wages relax existing liquidity constraints, long-run poor households are significantly better off than the respective rich ones. Since now the consumption tax rate remains almost constant, the reform only changes the taxation of different saving motives. Although highly elastic old-age savings are exempt from taxation, the aggregate efficiency gains are fairly small.

The left part of Table 7 shows that annuitization mainly reduces the welfare of newborn

are available on request.

[15]This corresponds with the results of Nishiyama and Smetters (2005) who find in a similar set-up an aggregate efficiency loss after a switch from income to consumption taxation.

and future generations. Already retired cohorts are only affected by the slightly higher consumption tax rate. Since former intergenerational transfers are substituted by transfers within a generation, working generations in the reform year are significantly better off than before. They still receive bequest from the elderly and benefit from increased longevity insurance. On the other hand, future generations are much worse off than before since they are hurt by the significant reduction of unintended bequest. In the long-run the welfare reduction amounts to 0.85 percent of remaining resources. Note that future generations lose although aggregate efficiency rises significantly by roughly 0.5 percent of aggregate resources. The latter reflects the value of the longevity insurance which is provided by the annuity.

Table 7: Welfare effects of annuitized retirement accounts

Age in	Annuitized IRA				German system			
reform	Consumers			compen-	Consumers			compen-
year	poor	median	rich	sated	poor	median	rich	sated
90-94	0.12	0.10	0.09	0.00	-0.14	-0.12	-0.11	0.00
80-84	0.10	0.09	0.06	0.00	-0.16	-0.13	-0.14	0.00
60-64	-0.10	-0.46	-0.66	0.00	-0.35	-0.68	-0.86	0.00
40-44	1.34	1.11	0.53	0.00	1.81	1.13	0.39	0.00
20-24	(0.40)	0.41	(0.55)	0.48	(0.58)	0.57	(0.60)	0.58
0-4	(-0.35)	-0.32	(-0.16)	0.48	(-0.19)	-0.17	(-0.13)	0.58
∞	(-0.90)	-0.85	(-0.74)	0.48	(-0.71)	-0.68	(-0.70)	0.58

[a]Change are reported in percentage of initial resources.

Finally, in the right part of Table 7 the German system of (optional) direct subsidies reduces welfare of retired households due to the increase in consumption taxes. As one would expect, low-income newborn and future households are better off compared to the previous simulation, but they still experience welfare losses from the reform. Of course, they benefit directly from the subsidies but they are also hurt by the higher consumption taxes. On the other hand, future rich households are almost not affected. Direct subsidies for low-income households improve the insurance properties of the tax system while they also distort labor supply. Since the insurance effect dominates the distortionary effect, the last column reports only a slight increase in aggregate economic efficiency compared to the previous simulation.

Table 8: Sensitivity analysis for the German system

η	γ	ρ	μ	δ	Changes in long-run savings	IRA share	wages	welfare	efficiency
4.0	0.5	0.6	0.0	0.91	**3.9**	**46.9**	**-0.6**	**-0.68**	**0.58**
0.0				0.97	4.7	51.5	-0.5	-0.81	0.12
	0.33			0.95	0.0	45.5	-1.4	-1.31	0.35
		1.5		0.95	7.0	45.1	0.5	-0.18	0.27
			0.7	0.84	7.9	30.3	0.5	0.24	0.25
Small open economy					3.1	46.7	0.0	-0.48	0.43

5.4 Sensitivity analysis

The positive efficiency effects and the negative long-run welfare effects of the German system turn out to be quite robust. Table 8 reports the long-run macroeconomic and welfare effects as well as efficiency consequences for alternative parameter combinations and economic assumptions. For better comparison the first line repeats (in bold numbers) the results for the benchmark case from Tables 3 and 7. With risk neutral agents (i.e. when $\eta = 0.0$) precautionary savings decrease so that the time preference rate has to increase in order to recalibrate the initial equilibrium with the same capital-output ratio as in Table 2. Risk neutral individuals react stronger to the tax incentives. Consequently, aggregate savings increase stronger and the long-run IRA share is higher than in the benchmark. Therefore, unintended bequest fall much stronger so that long-run welfare is even lower than in the benchmark. Since risk neutral individuals don't value the insurance provision of the annuitized accounts, the efficiency gain is reduced from 0.6 to 0.1 percent of aggregate resources. Note that this is very close to the aggregate efficiency gain in the traditional IRA system of Table 6. In both cases aggregate efficiency changes are mainly due to the separate taxation of different savings motives.

Next we reduce the intertemporal elasticity of substitution from 0.5 to 0.33. Since the consumption profile becomes flatter, initial savings fall and the time preference rate has to increase again to stabilize the capital-output ratio. Now savings incentives work much less than in the benchmark. Savings in retirement accounts mainly represent funds which are shifted from already existing accounts. As a consequence, aggregate savings remain constant in the long-run. Since public debt increases as before, the capital stock decreases much stronger and wages fall by 1.4 percent. The latter hurts future generations so that long-run welfare decreases more than in the benchmark. Aggregate efficiency increases slightly less than in the benchmark since intertemporal distortions are reduced less when the intertemporal elasticity of substitution is low.

In the following simulation we assume an extremely high (compensated) labor supply elasticity of about 1 by setting $\rho = 1.5$. In this case households work and save less in the initial equilibrium so that again the time preference rate has to increase. The reaction of labor supply is now much stronger than in the benchmark simulation. Employment even falls in the long-run by 0.7 percent. At the same time aggregate savings rise much stronger so that long-run wages now even increase by about 0.5 percent. Higher wages and higher bequest reduce the long-run welfare losses compared to the benchmark. Since the reform increases distortions of labor supply, aggregate efficiency decreases with a higher intratemporal elasticity of substitution.

Up to now people had no bequest motive. When we introduce such a "joy of bequest giving" motive, savings rise so that the time preference rate has to decrease significantly in order to recalibrate the initial equilibrium. A bequest motive has two major consequences. First, annuitized accounts are less attractive. Second, additional resources of the surviving elderly (from annuitized accounts) are now not consumed but saved for the descendants. As a consequence, aggregate savings increase quite strongly while at the same time the IRA share remains much low. Therefore, the capital stock increases much stronger so that wages rise and future generations even experience a welfare gain. Of course, since now people take less advantage of the insurance properties of accounts, aggregate efficiency decreases compared to the benchmark.

Finally, in the small open economy we can keep all parameters from the benchmark but keep factor prices constant. People save now slightly less compared to the benchmark and long-run generations lose slightly less due to constant wages. The aggregate efficiency gain is smaller compared to the benchmark probably because of the dampened savings reaction.

6 Discussion

This study intends to evaluate the macroeconomic and welfare consequences of the introduction of tax-favored "Riester pensions" in Germany. Since savings in the accounts are tax deferred, we assume that the government balances the intertemporal budget by the consumption tax so that public debt increases during the transition. We find a long-run decrease in the capital stock and wages of about 2 and 0.6 percent, respectively, although aggregate savings increase during the transition. The reform increases economic efficiency by roughly 0.6 percent of aggregate resources but reduces the welfare of future generations almost in the same relative amount. The efficiency gain is mostly due to the fact that the reform improves the insurance properties of the tax system and allows to tax different savings motives separately. Long-run welfare decreases because accidental bequest fall dramatically when retirement accounts include provisions for mandatory annuitization. Finally, the study indicates that the special provisions for low-income households are successful in increasing the participation of this group. However, the particular design of the German system has a negative side effect on labor supply.

Therefore, the present study highlights the importance of including transitional dynamics in tax and pension reform analysis. Since the long-run welfare changes are mainly due to intergenerational redistribution, they don't even indicate the direction of the overall efficiency effects. Our results confirm the back-of-the-envelop calculations in Fehr and Habermann (2008) who quantify efficiency efficiency effects of the introduction of annuities in a stylized model.

Of course, the simulated reforms could be extended in various directions. It is no problem to fully annuitize retirement account savings even before retirement, allow (as in Germany) to withdraw a lump-sum amount at time of retirement, or model a choice between an immediate annuitization at the beginning of retirement and a fixed pay-out plan combined with delayed annuitization. However, these extensions have only very minor effects on aggregate efficiency. Fehr, et al. (2008) also consider alternative financing scenarios, contribution ceilings and direct subsidy payments. While each reform design alters the intergenerational welfare consequences, the aggregate efficiency effect is hardly changed. Of course, it would be no problem to include additional elements of the German Riester reform such as the reduction of the unfunded public pension system. This extension would increase the incentives to contribute to the accounts but it would complicate the welfare analysis of Riester accounts. For this reason this extension is left to future research.

Appendix A: Computational method

In order to compute a solution we have to discretize the state space. The state of a household is determined by $z_j = (j, \mathrm{a}_j, \mathrm{a}_j^R, ep_j, e_j) \in \mathcal{J} \times A \times R \times P \times E_j$ where $\mathcal{J} = \{1, \ldots, J\}, A = \{\mathrm{a}^1, \ldots, \mathrm{a}^{n_A}\}, R = \{\mathrm{a}^{R,1}, \ldots, \mathrm{a}^{R,n_R}\}, P = \{ep^1, \ldots, ep^{n_P}\}$ and $E_j = \{e_j^1, \ldots, e_j^{n_E}\}$ are discrete sets. In this paper we use $J = 16, n_A = n_R = 12, n_P = 5$ and $n_E = 6$. The initial values for efficiencies are: $\xi(1, 0, 0, 0, e_1^1) = \xi(1, 0, 0, 0, e_1^2) = 0.1$ and $\xi(1, 0, 0, 0, e_1^3) = \cdots = \xi(1, 0, 0, 0, e_1^6) = 0.2$.

For all these possible states z_j we compute the optimal decision of households from (5). The pension grid is equidistant while the asset grid has increasing intervals between two grid points. This is useful since the value function is heavily curved for low values of assets. Since $u(c_j, \ell_j)$ is not differentiable in every (c_j, ℓ_j) and $V(z_{j+1})$ is only known in a discrete set of points $z_{j+1} \in \{j+1\} \times A \times R \times P \times E_j$, this maximization problem can not be solved analytically. Therefore we have to use the following numerical maximization and interpolation algorithms to compute households optimal decision:

1. Compute (5) in age J for all possible z_J. Notice that $V(z_{J+1}) = 0$ and households are not allowed to work anymore. Hence, in the optimum households should consume everything they have.

2. For $j = J - 1, \ldots, 1$:

   Find (5) for all possible z_j by using Powell's algorithm (Press et. al., 2001, 406ff.). Since this algorithm requires a continuous function, we have to interpolate $V(z_{j+1})$. Having computed the data $V(z_{j+1})$ for all $z_{j+1} \in \{j+1\} \times A \times R \times P \times E_j$ in the last step, we can now find a function sp_{j+1} which satisfies the interpolation conditions

   $$sp_{j+1}(j+1, \mathrm{a}_{j+1}^k, \mathrm{a}_{j+1}^{R,l}, ep_{j+1}^m) = EV(z_{j+1}) \tag{26}$$

   for all $k = 1, \ldots, n_A$, $l = 1, \ldots, n_R$ and $m = 1, \ldots, n_P$. In this paper we use multidimensional cubic spline interpolation, i.e. $sp_j : \mathcal{S}_3 \times \mathcal{S}_3 \times \mathcal{S}_3 \to \mathbb{R}$, whereas $\mathcal{S}_3$ is the space of all one-dimensional, twice continuously differentiable, piecewise third-order polynomial functions and $\mathcal{S}_3 \times \mathcal{S}_3 \times \mathcal{S}_3$ is its tensor product (cf. Judd (1998, 225ff.)). For further information see Habermann and Kindermann (2007).

Appendix B: Markov transition matrices

Age dependent Markov transition matrices

		Age 20-24 Future productivity level						Age 25-29 Future productivity level					
		1	2	3	4	5	6	1	2	3	4	5	6
	1	0.30	0.16	0.27	0.07	0.06	0.13	0.31	0.17	0.22	0.08	0.10	0.11
	2	0.15	0.18	0.19	0.24	0.12	0.13	0.15	0.22	0.28	0.13	0.10	0.11
Current	3	0.07	0.18	0.39	0.17	0.12	0.08	0.08	0.11	0.33	0.25	0.14	0.09
productivity	4	0.09	0.07	0.15	0.33	0.22	0.15	0.08	0.08	0.21	0.31	0.22	0.09
level	5	0.07	0.05	0.13	0.24	0.34	0.17	0.05	0.05	0.12	0.21	0.32	0.24
	6	0.05	0.04	0.10	0.12	0.23	0.46	0.06	0.06	0.09	0.12	0.22	0.46

		Age 30-34 Future productivity level						Age 35-39 Future productivity level					
		1	2	3	4	5	6	1	2	3	4	5	6
	1	0.33	0.22	0.21	0.09	0.09	0.07	0.37	0.20	0.22	0.13	0.05	0.05
	2	0.18	0.25	0.30	0.14	0.05	0.07	0.22	0.29	0.32	0.12	0.03	0.02
Current	3	0.09	0.15	0.35	0.24	0.11	0.06	0.12	0.16	0.38	0.20	0.09	0.05
productivity	4	0.07	0.06	0.24	0.33	0.21	0.09	0.04	0.04	0.24	0.40	0.22	0.07
level	5	0.05	0.02	0.11	0.24	0.38	0.20	0.02	0.04	0.07	0.21	0.44	0.22
	6	0.03	0.04	0.05	0.08	0.23	0.58	0.02	0.02	0.04	0.07	0.22	0.63

		Age 40-44 Future productivity level						Age 45-49 Future productivity level					
		1	2	3	4	5	6	1	2	3	4	5	6
	1	0.49	0.24	0.15	0.04	0.06	0.02	0.45	0.26	0.22	0.04	0.01	0.01
	2	0.17	0.31	0.36	0.09	0.05	0.03	0.15	0.32	0.33	0.14	0.03	0.03
Current	3	0.07	0.13	0.40	0.25	0.10	0.05	0.08	0.11	0.44	0.27	0.07	0.02
productivity	4	0.06	0.06	0.20	0.40	0.21	0.08	0.05	0.04	0.16	0.40	0.29	0.06
level	5	0.02	0.02	0.09	0.21	0.47	0.18	0.04	0.02	0.08	0.19	0.46	0.20
	6	0.02	0.02	0.05	0.07	0.16	0.66	0.02	0.03	0.05	0.04	0.15	0.70

		Age 50-54 Future productivity level					
		1	2	3	4	5	6
	1	0.42	0.22	0.21	0.07	0.04	0.04
	2	0.14	0.30	0.35	0.11	0.06	0.04
Current	3	0.11	0.12	0.37	0.25	0.11	0.03
productivity	4	0.04	0.05	0.19	0.41	0.24	0.07
level	5	0.04	0.03	0.09	0.20	0.45	0.19
	6	0.03	0.05	0.07	0.05	0.15	0.66

Source: Authors' own calculations from 1984-2001 SOEP data

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